

# Determination of Measles Immunity After a Mass Immunization Campaign

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SINCE 1966, when the Public Health Service outlined a plan for eradicating measles in the United States (1), many communities have conducted mass immunization campaigns against measles. The success of these campaigns has been measured by the estimated proportion of susceptible persons who have been immunized. In many parts of the country, including Florida, the target group or estimated number of susceptible children, 1 through 12 years old before the campaign, has been obtained by multiplying the total population of the area by 5 percent (2) or 6 percent (3). The figure most widely used, 6 percent, results from surveys in

Rhode Island before mass measles campaigns there (3).

The metropolitan Detroit area campaign of October 23, 1966, in which 170,000 children in a population of 4,090,000 were immunized (4.2 percent), was considered a success (4). Similarly, the Memphis and Shelby County (Tenn.) campaign was considered successful: 33,843 children in a population of 739,000 (4.6 percent) were immunized March 19-24, 1967 (5). Many similar programs have been considerably less successful.

A stratified random survey in Hillsborough County, Fla., 1 month after a mass immunization campaign provided a unique opportunity to evaluate measles immunity and program success in a metropolitan area.

## Method of Procedure

*Mass immunization campaign.* The Hillsborough County Pediatric Society sponsored the campaign, with the cooperation of the Hillsborough County Health Department, Florida State Board of Health, and National Communicable Disease Center (NCDC) of the Public Health Service. Two months were spent in planning and preparing the program. Eleven community organizations actively participated. For example, the Tampa Junior Chamber of Commerce provided transportation, the Tampa Junior Woman's Club made posters to publicize the campaign and helped at the clinics, and the

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staff of the Hillsborough Association for Retarded Children went from door to door in the poverty areas inviting the residents to participate. The campaign was widely publicized by television, radio, and newspapers, and by posters and notices in the schools. In addition, Spanish-speaking physicians discussed the program before hard-to-reach groups.

The target population was estimated to be 28,000 children, 1 through 12 years old. This number was obtained by multiplying the population of Hillsborough County including the City of Tampa, approximately 466,500, by 6 percent. A total of 26,172 children, or 94 percent of the target population, was vaccinated on January 21, 1968.

*Viral Immunity Survey.* From February 26 to March 8, 1968, a viral immunity survey was conducted in Hillsborough County by the health department, Florida State Board of Health, and NCDC. The Serfling-Sherman probability sampling technique developed at NCDC (6) was used. Full details of the selection process are described elsewhere. (E. C. Prather, G. Case, O. Boorde, and T. Collins: Immunity to childhood diseases in a metropolitan area. Unpublished paper.) A brief description of the methodology follows.

The county was divided into five socioeconomic areas, based on 1960 U.S. census tract data: urban upper, urban middle, urban lower, suburban, and rural. NCDC sampling points were then allocated to the various areas according to the latest (1967) population estimates to maximize the size of the younger age groups. Thus more families were sampled in the urban upper area to compensate for the smaller families than in the urban middle area. The total survey population included 2,881 persons in 906 families.

Epidemiologic data on mumps, measles, rubella, arbovirus encephalitis, and poliomyelitis were collected. Blood specimens were obtained from 2,019 persons in 761 families. The respondents were asked if a given family member had a history of measles and, if so, the age of the patient at onset. Then, the respondent was asked if a given member had ever received measles vaccine and, if so, at what age and from whom. The interviewers were supplied with definitions of measles and rubella to minimize subjective responses by either the interviewer or the respondent.

*Serology.* All serologic tests for measles antibody were performed in NCDC laboratories. The serums were tested by the hemagglutina-

**Table 1. Measles susceptibility status among 1- through 12-year-old children 1 month after a mass immunization campaign in Hillsborough County on Jan. 21, 1968, by geo-socio-economic group**

| Status   | Urban                |        |       |                 | Suburban | Rural |
|--|----------------------|--------|-------|-----------------|----------|-------|
|  | Upper                | Middle | Lower | Total           |          |       |
|  | Number               |        |       |                 |          |       |
| A Children surveyed.....                                       | 116                  | 140    | 172   | -----           | 134      | 174   |
| B History of rubeola or vaccine before campaign.....           | 79                   | 82     | 95    | -----           | 75       | 91    |
| C Susceptibles before campaign (A-B).....                      | 37                   | 58     | 77    | -----           | 59       | 83    |
| D Susceptibles, by history, receiving vaccine in campaign..... | 23                   | 26     | 40    | -----           | 20       | 36    |
|  | Percent <sup>1</sup> |        |       |                 |          |       |
| E Susceptibles before campaign (C÷A)....                       | 31.9                 | 41.4   | 44.8  | <sup>2</sup> 41 | 44.0     | 47.7  |
| F Susceptibles, by history, reached in campaign (D÷C).....     | 62.2                 | 44.8   | 51.9  | <sup>2</sup> 50 | 33.9     | 43.4  |
| G Still susceptible after campaign (C-D÷A)....                 | 12.1                 | 22.9   | 21.5  | <sup>2</sup> 20 | 29.1     | 27.0  |
| H Change in immunity level due to campaign (E-G).....          | 19.8                 | 18.5   | 23.3  | <sup>2</sup> 21 | 14.9     | 20.7  |

<sup>1</sup> Percentages calculated by using appropriate weighting factors for the sampling ratios employed in the original sample allocation. Because all areas were not

surveyed, total figures could not be obtained for the county.

<sup>2</sup> Approximate percentages.

tion-inhibition (HI) technique. The method was a quantitatively scaled-down version of the macro method of Rosen (7) with 0.025 milliliter (ml.) of treated serum dilutions, 0.025 ml. of antigen (4 hemagglutinating or HA units), and 0.05 ml. of a 0.5 percent suspension of monkey erythrocytes. Erythrocytes from the African green or *Cercopithecus aethiops* monkeys rather than those from rhesus monkeys were used. The HA antigen was prepared from the Philadelphia 26 strain of measles virus grown on primary human amnion. The antigen was treated by Tween 80 and ether, according to Norrby (8). Serums were absorbed with 50 percent monkey erythrocytes before tests were performed.

*Followup.* Routine procedures of the Hillsborough County Health Department were used for surveillance of measles cases after the campaign; in addition, pediatricians were encouraged to report cases. Routinely, all practicing physicians receive reporting cards from the health department on a weekly basis to facilitate the reporting of communicable diseases. Each reported case of measles was reviewed by a public health nurse or a physician, and the reporting physician was called to verify the diagnosis. Serologic confirmation of cases was not attempted.

### Results of the Campaign

Of the 26,172 children who reported to the 25 clinics on January 21, 1968, and were given measles vaccine by jet injector, 12,464 were under 6 years old; the remaining 13,708 were 6 through 12 years old. The number immunized equaled 5.6 percent of the total population of the area. Since the estimated target population

was 28,000, we presumed that essentially all the susceptible children had been immunized.

*Immunity as measured by history of measles or vaccine.* The survey results concerning measles susceptibility status before the campaign of those aged 1 through 12 are shown in table 1. The proportion of susceptible children, by history, before the campaign varied from 31.9 to 47.7 percent. Upper socioeconomic urban Tampa had a susceptibility rate of only 31.9 percent, while lower socioeconomic urban Tampa had a rate of 44.8 percent. A considerable proportion of children in all the geo-socioeconomic groups remained susceptible, by history, after the campaign. In urban Tampa 20 percent remained susceptible; the proportions were even higher in suburban (29.1 percent) and rural (27.0 percent) Tampa. The increase in immune children as a result of the campaign varied from 14.9 to 23.3 percent, suggesting that the lower socioeconomic group in urban Tampa benefited most from the campaign.

*Immunity as measured by measles antibody.* Measles immunity as determined by the presence or absence of measles antibody in all children in the survey sample, 3 through 12 years old, who submitted blood specimens, regardless of history, is shown in table 2. The proportion of immune children in each geo-socioeconomic category was equal to or greater than that obtained by history alone (table 1).

*Correlation of history and blood sample results.* Correlations of history of rubeola or rubeola vaccine and presence or absence of measles antibody in children 3 through 12 years old who submitted blood specimens are shown in table 3. If the presence of measles antibody

**Table 2. Immunity among geo-socioeconomic groups as measured by presence or absence of measles antibody in children 3 through 12 years old, who submitted blood specimens, regardless of history, viral immunity survey, February-March 1968**

| Age group (years) | Urban upper               |                                    | Urban middle              |                       | Urban lower               |                       | Suburban                  |                       | Rural                     |                       |
|-------------------|---------------------------|------------------------------------|---------------------------|-----------------------|---------------------------|-----------------------|---------------------------|-----------------------|---------------------------|-----------------------|
|                   | Number of serums examined | Percent with antibody <sup>1</sup> | Number of serums examined | Percent with antibody | Number of serums examined | Percent with antibody | Number of serums examined | Percent with antibody | Number of serums examined | Percent with antibody |
| 3-4----           | 3                         | 67                                 | 18                        | 78                    | 14                        | 71                    | 5                         | 60                    | 6                         | 67                    |
| 5-9----           | 23                        | 87                                 | 41                        | 93                    | 72                        | 97                    | 52                        | 96                    | 40                        | 88                    |
| 10-12---          | 23                        | 96                                 | 26                        | 96                    | 26                        | 100                   | 22                        | 100                   | 43                        | 100                   |

<sup>1</sup> Titer  $\geq 1:4$ .

**Table 3. Correlation of history of rubeola and vaccine with blood specimen results for children 3 through 12 years old, viral immunity survey, February–March 1968**

| Blood specimen results             | Positive history of measles or vaccine | Negative history of measles or vaccine | Total            |
|------------------------------------|--|--|------------------|
| Positive antibody <sup>1</sup> --- | 317                                    | 57                                     | 374              |
| Negative antibody ---              | 16                                     | 14                                     | 30               |
| Total..                            | 333                                    | 71                                     | <sup>2</sup> 404 |

<sup>1</sup> Titer  $\geq 1:4$ .

<sup>2</sup> History of 10 of the 414 children who submitted blood specimens was uncertain; therefore, they were omitted from this table.

is considered as the most reliable indicator of past measles infection, 82 percent of the history and blood specimen results were in agreement ( $317 + 14 \div 404$ ); there were 80 percent false negative histories ( $57 \div 71$ ) and 4.8 percent false positive histories ( $16 \div 333$ ). Since the inapparent infection rate in rubeola is considered to be quite low (9), the observed differences are probably the result of poor memory. Significant differences were observed between geo-socio-economic groups in these correlations. Agreement was 92 percent in the urban upper area, 85 percent in the urban middle area, 81 percent in the urban lower area, 69 percent in the sub-urban area, and 87 percent in the rural area.

*Followup.* In the year after the mass measles campaign, only 49 cases of measles were reported to the health department as compared with 524 the year before and at least 485 in each of the preceding 10 years. Investigation revealed that 40 of the 49 cases called measles in the followup period were actually cases of rubella. Of the nine cases of true rubeola, three were in girls and six in boys. Of the nine patients, three were 1 year old or less, and none had ever received measles vaccine.

### Discussion

Our survey revealed that the mass immunization campaign against measles was not as successful in reducing the number of susceptible children in Hillsborough County as had been anticipated. By vaccinating 26,172 of the 28,000

target children on January 21, we supposed that 94 percent of the susceptible children had become immune, but the survey indicated that only about 50 percent had been immunized in the campaign.

One reason for the discrepancy is that the true proportion of susceptible children was nearer 10 than 6 percent of the total population. If 41 percent of 115,000 (total number in 1 through 12 age group) is estimated as the proportion of susceptible children before the campaign (table 1), about 47,000 children would be in this group, or approximately 10 percent of the January 1968 estimated population of 466,500 in Hillsborough County.

Another reason for the discrepancy indicated by the survey was that children above and below the age limits were also vaccinated on January 21 and counted, as were the children who had rubeola. Also, clinic workers reported that, as a result of the widespread publicity, some children who were vaccinated in Hillsborough County came from other counties. We suspect that such sources of error in rating a mass campaign a success are not unique to Hillsborough County.

Lennon and co-workers (10) noted considerable variation in measles history and vaccination status in a metropolitan community, depending on economic and geographic factors. Similarly, considerable variation must exist among other communities, and generalized estimates of the number of susceptible persons are hazardous.

Despite our finding that only about half of the susceptible children had been immunized during the campaign, the program had a dramatic effect on the incidence of measles. The reported number of measles cases fell by a factor of 10 in the year after the campaign as compared with the previous year, even if the rubella cases mistakenly reported in the followup period were not excluded. The most likely explanation for this dramatic decrease is herd immunity. Hedrich (11) and Schaffner and co-workers (12) predicted that only 55 to 65 percent of children under age 15 in a community need be immune to measles to prevent outbreaks. The immunity level in Hillsborough County after the campaign was higher than 70 percent.

We learned the following lessons from the

Hillsborough County mass immunization campaign against measles:

1. It is hazardous to apply generalized estimates in determining the number of children who are susceptible to measles in a given population. Precampaign and post campaign surveys, although costly, provide more accurate estimates of the target population and the degree of success.

2. A dramatic drop in incidence of measles can result from a modest rise in immunity against measles in a metropolitan area.

3. A significant number of children who are susceptible to measles may persist after a successful campaign. Therefore, mass campaigns, no matter how well planned and executed, must be supplemented by vigorous, ongoing immunization activities to achieve eradication of the disease.

### Summary and Conclusion

Six percent of the total population of 466,500 in Hillsborough County, Fla., was used as the estimated target population of children susceptible to measles before a mass immunization campaign against the disease. During the campaign on January 21, 1968, a total of 26,172 children, 1 through 12 years old, or 94 percent of the target population were vaccinated. One month later a random viral immunity survey set up in socioeconomic areas to determine the results of the campaign indicated that only about 50 percent of the susceptible children in the target population, rather than the 94 percent expected, had been immunized.

Despite the finding that only about half of the susceptible children in the target population had been immunized during the campaign, the program had a dramatic effect on the incidence of measles. The reported number of measles cases fell by a factor of 10 in the year after the campaign as compared with the previous year.

This study illustrates the hazards of using generalized estimates to determine target populations, yet shows that dramatic decreases in the incidence of measles can occur with only modest boosts in immunity in key populations.

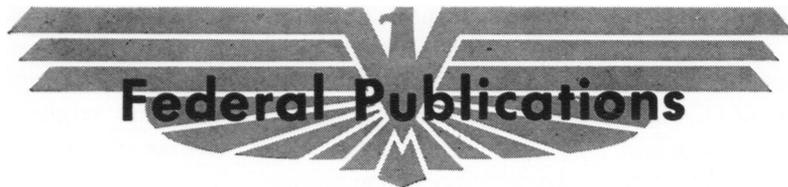
Since a significant number of children who are susceptible to measles may persist after a successful campaign, it would seem that mass campaigns must be supplemented by vigorous ongoing immunization activities to achieve eradication of the disease.

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### Teensheet Requests

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**Grants-In-Aid and Other Financial Assistance Programs, Health Services and Mental Health Administration, 1968-1969 edition.** *PHS Publication No. 1945; 1969; 62 pages.* Lists and describes the various forms of financial aid administered by the Health Services and Mental Health Administration. Presents uniformly certain kinds of information on each type of aid—purpose, financing, method for determining how Federal funds are allocated, matching requirements, who may receive Federal funds, how application for funds is made, recent developments, the legal basis on which funds are made available, and the office of the Administration from which additional information may be obtained.

**Summaries of Solid Wastes Program Contracts, July 1, 1965-June 30, 1968.** *PHS Publication No. 1897; by Clarence A. Clemons and Ralph J. Black; 1969; 46 pages; 65 cents.* Contains abstracts on the 42 contracts undertaken from the beginning of activities conducted with funds appropriated under the Solid Waste Disposal Act through June 1968. Subjects range from appraisals of current solid waste practices in Western Europe and this country to the development of a new solid waste technology.

**Film Guide on Reproduction and Development.** *National Institute of Child Health and Human Development. 1969; 66 pages; \$1.25.*

Designed to be used in teaching and research settings in colleges, universities, and graduate schools, the guide describes 26 films selected for their excellence by a group of scientists and university educators who served as consultants to the Institute in this project.

The film guide was developed by the Mental Health Materials Center

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Covers such fundamental processes of early development as cell differentiation, gametogenesis, fertilization, implantation, and development through organogenesis. Films are grouped under six main topics: structure and function of cells; mitosis and meiosis; development of invertebrata, osteichthyes, and amphibia; differentiation and organogenesis; courtship and reproduction; and techniques. Each entry contains a description of the content, notes on audience suitability, where and how obtainable, and a physical description—year produced, whether sound and color, and running time. Also includes an evaluation of the film's usefulness by the consultants who reviewed it.

#### Statistics From the National Health Survey

**PLAN AND OPERATION OF A HEALTH EXAMINATION SURVEY OF U.S. YOUTHS, 12-17 YEARS OF AGE.** *PHS Publication No. 1000, Series 1, No. 8; September 1969; 80 pages; 75 cents.*

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**TYPES OF INJURIES, INCIDENCE AND ASSOCIATED DISABILITY, United States, July 1965-June 1967.** *PHS Publication No. 1000, Series 10, No. 57; October 1969; 54 pages; 60 cents.*

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**Suicide Among American Indians. Two workshops.** *PHS Publication No. 1903; June 1969; 37 pages; 50 cents.* Contains papers from two workshops held in Aberdeen, S. Dak., September 1967 and in Lewistown, Mont., November 1967, sponsored by the National Institute of Mental Health and the Indian Health Service. Contains papers entitled Suicide in the United States; Self-destructive behavior in adolescents and adults: Similarities and differences; Two types of suicidal behavior; Planning for suicide prevention; Mental health services in a sparsely populated area: A necessary complement to a suicide prevention program; Suicide and self-destructive behavior in the Oglala Sioux: Some clinical aspects and community approaches; and Suicide and self-destructive behavior on the Cheyenne River Reservation.

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